

The Description and Uses of
BARSTON's
New-Invented Universal
Astronomical Quadrant,

Which appears from authentick Certificates transmitted to the Right Honourable the Lords of the Admiralty, to excel all others in Navigation; and from repeated Experiments of able Astronomers, &c. to be more serviceable in *Astronomy, Surveying of Land, and Dialling*, than any other hitherto Invented.

See its following Excellencies:

- I. It requires no Shade from the Sun.
- II. Nor any visible Horizon.
- III. 'Tis not so liable to be affected by the Motion of the Ship.
- IV. An Observation may be taken with it in the Night, (of which there are more frequent Opportunities than in the Day) either of the Moon or Fixed Stars, and the Latitude of the Place be thereby exactly determined.
- V. In this Instrument there is nothing required, but that you see the Object, viz. Sun, Moon, or Star; whereas in all others you are oblig'd to see two Objects at one and the same time; besides the difficulty of moving the Sliding-Pieces with the Finger, which while the Observer is doing, the opportunity of taking the Observation is many times lost.
- VI. It divides a Degree into 60 equal Parts, whereby the Altitude is shewn to a Minute, and, consequently, the Latitude of the Place to a Mile at Sea.

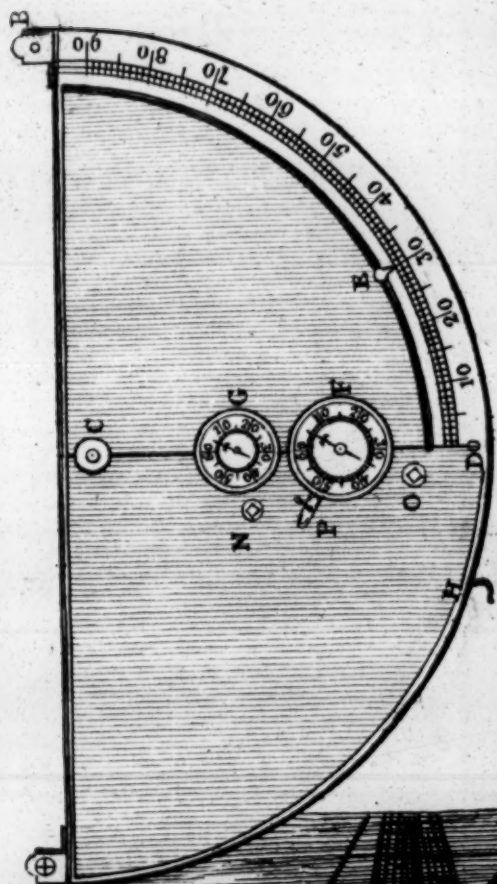
By which it appears, that the Altitude of any Heavenly Body may be more accurately, quicker, and much easier taken by this Instrument than any other whatsoever, since nothing is requir'd but the bare sight of the Object.

L O N D O N Printed: And Sold by T. COX at the Lamb-
under the Royal-Exchange: And J. TURNER at the Sign of
the *Quadrant and Dial* in Hatton-Garden. M.DCC.XL.
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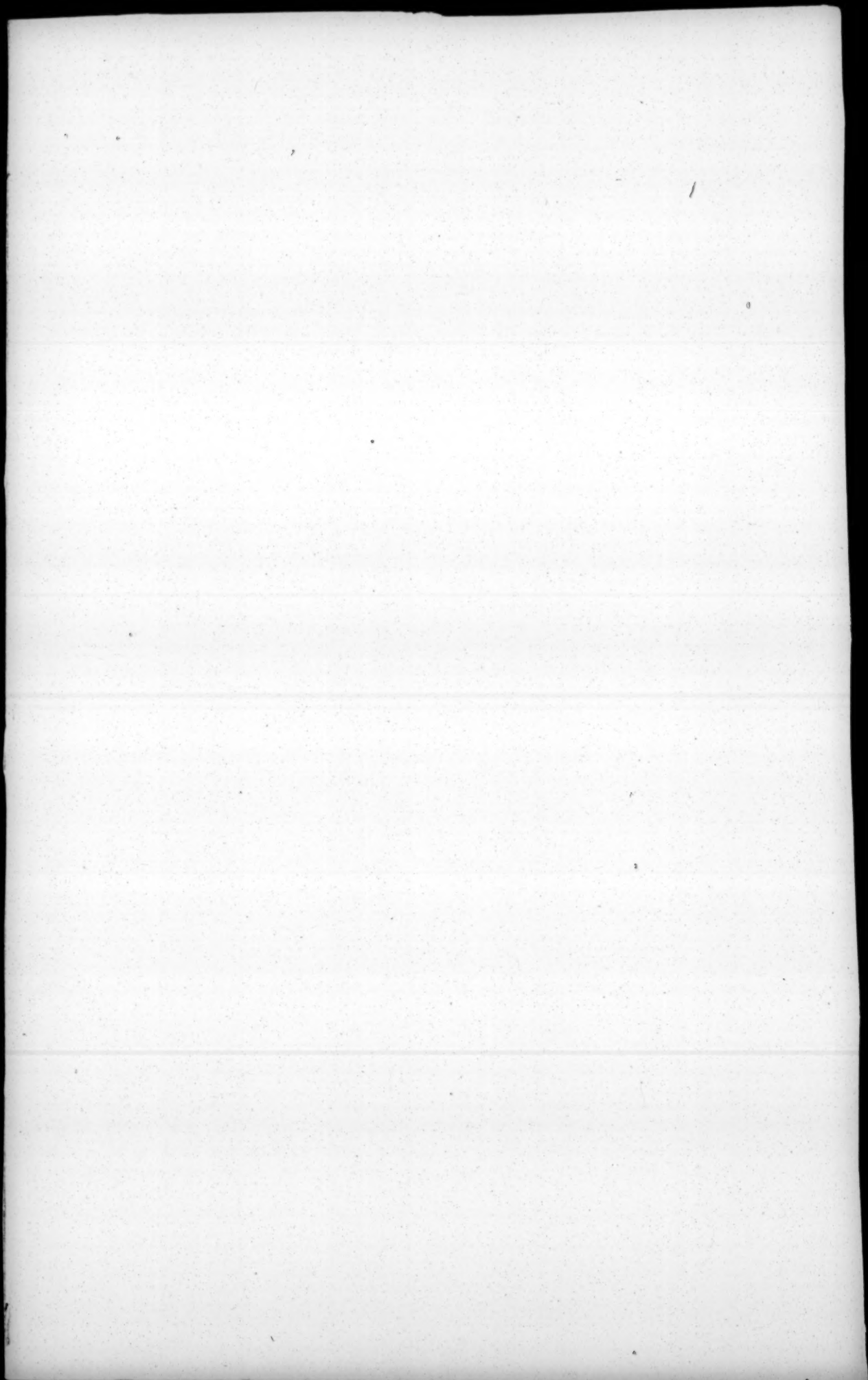
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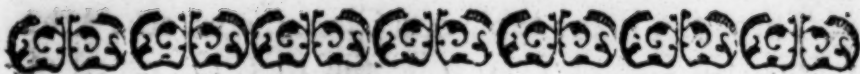












T H E
P R E F A C E.



S avery particular and accurate Account of the Use and Excellence of this new-invented *Quadrant* in *Navigation*, *Astronomy*, *Surveying of Land*, and *Dialling*, &c. is given in the following Treatise, it will be necessary in this short *Preface*, only to describe its external Figure, and to shew wherein it differs from all the other *Quadrants* now in Use.

Its Figure (as drawn in the prefix'd Plate) is a Semicircle whose Diameter from *A* to *B*, where the open Sights are fix'd, is 20 Inches, the Radius from *C* to *D* is 10 Inches; half the Limb is divided into 90 Degrees for Navigation, and the whole Limb into 180 Degrees for the several Uses at Land, and figur'd at every 5th Degree, while the Index *E* moves one Degree on the Limb, the Index *F* moves once round the Dial, and consequently shews the 60 Part of a Degree; the Index *G* moves once round to every of that 60 Part, by which means a Degree of Altitude is divided into 3600 equal Parts; but it is deem'd too minute for Sea Uses, and would also make 'em so Expensive, that few, perhaps, will care to purchase them; therefore I chuse, for common Sea Uses, to make them with Degrees and Minutes only, and with Seconds for Persons who are willing to be at the Expence of them on a Pedestal, for Land Uses in Astronomy, &c. The long Index *I K* with Sights at each end, is to be used in Surveying of Land and taking
Angles.

Angles in the Field, and thus it supplies the use of the Theodolite, Plane-table and Circumferentor. *M* the Needle, the Center *L* is to be put on *C* the center of the Instrument, and then it will be fit for that Purpose when put on the three-legged Staff. For more accurate Observations any Person may have Telescopal Sights, to put on and take off at pleasure. *H* is the Tricker, at which keep your Finger, and upon properly seeing the Object look'd for; pull it; (in like manner as firing of a Gun) by which means you'll have the Elevation of any heavenly Body to the 60 Part of a Degree. *P* a little brass Ball, by giving it a gentle push up, with your Thumb, from the small Dial *F*, then will the Indexes be free and ready for another Observation. *N* a Square, by putting on a Key the Seconds are to slide on or off, and the Instrument to perform with Degrees and Minutes only, or otherwise at pleasure. *O* a Square on which a Key is put to lock up the Work, so that in whatever position the Instrument may be in, by Carriage or otherways, it's not liable to be injur'd. The manner of using it is so obvious, that it is almost impossible not to apprehend it at first sight; however, to prevent Mistakes, such Directions are given in the first Chap. of this Treatise, as are sufficient to make any Person perfectly understand it. As the bare Assertion of the Inventor, tho' grounded upon the most certain Evidence, may be thought insufficient to recommend his Invention, it may be necessary to subjoin the Testimonies of the Learned Mr. *Whiston*, Mr. *Witty*, and Mr. *Hodgson*, the first of whom, in his Preface to the *Longitude Discover'd*, says, "Mr. *Barston's* Quadrant
 " altho' it were first intended by the Author for taking
 " the *Latitude*, in which Case it has met with great
 " Approbation; yet does it, moreover, seem to be
 " the best Instrument, hitherto known, for the per-
 " fecting the Discovery of the *Longitude* also, when-
 " ever neither the rising nor the setting of the Sun,
 Moon,

“ Moon, or Stars can be seen at Sea, &c. — This Gentleman farther observes, “ That upon the first “ Direction of its Sights to the Object, which are at “ the distance of an intire Diameter, as abovementi- “ oned, by this *Quadrant* the true altitude of the Sun, “ or Moon, or Fix’d Stars, or Planets, or Comets, may “ be, at any time, taken, both at Sea and at Land, as “ has been frequently experienc’d, nearly to a single “ Minute. Which altitude of the heavenly Bodies is “ always the best way of finding the *Latitude* directly; “ as it is frequently the best way of finding the time “ at the Ship also: without which the *Longitude* itself “ cannot be discover’d, either by Clocks, or by “ the Eclipses, Occultations, and Conjunctions of “ *Jupiter’s* Planets; or by the Appulses of the Moon “ to the Fix’d Stars, as all Astronomers do very well “ know. Nor indeed do I at all differ from Mr. *Witty* “ or Mr. *Hodgson*, in the value of such an Instrument; “ when it is affirm’d (*System of the Mathematicks*, “ *Vol. I. p. 382, 383.*) that he who can contrive any “ way to take the Height of any Fixed Star at Sea, “ to a Minute or two, may fairly be entitl’d to a “ Share of the Discovery of the *Longitude*, and ought “ to have a proportionable Reward.”

For many Years have the most able and skilful Navigators, thought it highly necessary (with regard to the Preservation of Mens Lives, as well as to the safety of Ships and their Cargo’s) that new and correct Draughts and Charts be made, of all the Trading Sea-Ports in the World, which may now be done, with much greater Ease and more Exactness by this new Quadrant, than could possibly be expected from any other whatsoever, because with it an altitude of the Sun, or Stars, may be taken oftner, and truer, than by any now in use; from whence ’tis reasonable to conclude, that, in a short time, all the Trading Sea-Ports, may be laid down in their true Distances
from

from the Equator, or the elevation of the Pole above the Horizon truly determined; and thus the Latitude of the Place might be depended on; which at this day most of them are so wide from Truth, that we have often lamented the Misfortune that has, and do daily attend our Ships at Sea, for want of better Sea-Charts; therefore 'tis hop'd the careful Mariner will make Observations at all the Ports he comes at, and keep an exact Register, by which we shall be enabled to delineate new Plans, to the Safeguard of Shipping and Honour of our *English* Nation.

In the following Pages are given a plain Description of the several Uses of this new *Quadrant*, in *Navigation*, *Astronomy*, *Surveying of Land*, *Dialling*, and in all other Arts where Angles are concerned..

Nothing now remains but to acquaint the Reader that His Majesty, in Consideration of the great Usefulness of this Instrument to the Trade and Navigation of these Kingdoms, has been Graciously pleas'd to Grant His Royal Letters Patent under his Great Seal, to the Inventor, *John Barston* and Assigns, for the sole Making and Vending the same: And that the said *John Barston*, for the better carrying on the Business of Making and Vending the said Instruments, has found it necessary to Assign over one Moiety of the Patent to Mr. *Joseph Turner* of *Hatton-Garden, London*, Watchmaker; at whose House the abovesaid Instruments are Made and Sold.

CHAP. I.

NAVIGATION is one of the usefulest Branches of the Mathematicks, for by it we have the Riches of foreign Countries brought safe to us; and all which depends upon Instruments for taking of Altitudes of the Sun and Stars, for determining the Latitude of the Ship at Sea, for finding the Sun's Azimuth, and thereby the variation of the Compass.

How to take an Altitude at Sea.

In order then to take an altitude of the Sun or Stars at Sea, come on Deck, take the Quadrant in your Hand and raise it gently till you see the Sun or Star, through the Sights, then with your Finger pull the Tricker *H*, and it stops the Hands *E* and *F*, and gives you the Altitude in Degrees and Minutes.

The Latitude of a Place is always equal to the Height of the Pole, or Arch of the Meridian between the Pole and Horizon, which is equal to the distance of the Ship from the Equinoctial; which in the Schemes of the second Chapter OP is equal to $Z\text{ } \mathcal{A}$

the Latitude. As the Declination of the Sun or Star is measured by an Arch of the Meridian intercepted between the Sun or Star and the Equator; so that here the Declination apply'd (as we shall shew by and by) to the Altitude will give the Latitude the Ship is in, and this by a simple Addition or Subtraction only; but upon any other Azimuth it will require the solution of a Spheric Triangle: Therefore, for these Reasons, Seamen chuse to wait for the Sun or Star being upon the Meridian, and then by the Instrument abovemention'd they take the Zenith Distance of the Sun or Star, and thereby gain the Latitude of the Ship: The Zenith Distance is no more than the Complement of the Altitude; as in *Scheme I. p. 13.* *HD* is the meridian Altitude, which if we take from *HZ* there will remain *DZ* the Complement or Zenith Distance. Now to find the Latitude of the Ship at Sea, the following Rules and Examples will make very plain.

Rule I. If the Sun or Star be in the Equator and have no Declination, the meridional Zenith Distance is equal to the Latitude of the Place; which if the Sun or Star be to the South of you, the Ship is in North Latitude, but if to the North of you, then the Latitude is South.

II. If the Sun or Star appear in the Zenith, then the Latitude of the Place is equal to the Declination, and is of the same Name; that is, if the Declination be North, the Latitude is North; if South, the Latitude of the Ship is South.

III. If the Sun or Star appear neither in the Zenith nor in the Equator, and consequently have both Zenith Distance and Declination, if these are both North, or both South, and the Zenith Distance greater than the Declination, then subtract the Declination from the Zenith Distance, gives the Latitude of the Ship; and is North, if the Zenith Distance and Declination be South; but if they be North, the Latitude is South.

Example.

Example. Admit at Sea you observe the Sun on the Meridian $40^{\circ} 54'$ from the Zenith Southward, and the Sun's Declination $15^{\circ} 45'$ South, What's the Latitude of Observation?

Sun's Zenith Distance South	$40^{\circ} 54'$
Sun's Declination South	$15 \quad 45$

Remains Latitude North $25 \quad 9$

IV. If the Declination and Zenith Distance are equal, the Ship then is under the Equinoctial, and consequently the Latitude is nothing, neither Pole being elevated.

V. If the Meridional Zenith Distance and the Sun's Declination be of contrary Names, *viz.* one North and the other South, their Sum is the Latitude of the Place, and is always of the same Name with the Declination.

Example. Admit at Sea the Sun's Meridional Zenith Distance $36^{\circ} 54'$, and the Declination South $14^{\circ} 38'$, I demand the Latitude of the Place of Observation? *See the Work.*

Sun's Zenith Distance North	$36^{\circ} 54'$
Sun's Declination South, add	$14 \quad 38$

Sum is the Latitude South $51 \quad 32$

Note, It is to be observed here, that when the Latitude of the Place is greater than the Complement of the Declination, and both the same way, that the Sun or Star will not set in that Latitude, but transit the Meridian above and below the Pole, twice in 12 Hours. From the greatest Meridional Zenith Distance take the least, and half the remainder is the Complement of the Latitude of the Place, which is North, if the greater of the two given Zenith Distances be North, but South if the greater of the two given Zenith Distances be South.

Example. Admit at Sea you observe the Sun upon the Meridian to the South $24^{\circ} 30'$ and 12 Hours

after you observe the Sun on the Meridian to the North $17^{\circ} 52'$, What's the Latitude of the Place, and whether North or South?

Zenith Distances	{	$72^{\circ} 8'$
		$65 \quad 30$

Difference	$6 \quad 38$
half the Remainder, subtract	$3 \quad 19$
	from $90 \quad 00$

Remains the Latitude North $86 \quad 41$

Or thus by Addition, by knowing the Sun's Declin.

Sun's South Zenith Distance	$65 \quad 30$
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Declination North add	$21 \quad 11$
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Sum is the Latitude North	$86 \quad 41$
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2. Admit at Sea the Sun be observed twice in 12 Hours on the Meridian, and he having then South Declination, and his South Meridian Altitude is $12^{\circ} 40'$, the second is $29^{\circ} 56'$ Northward; I demand the Latitude, and whether North or South?

Operation.

From the greater Meridian Altitude	$29^{\circ} \quad 56'$
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Subtract the lesser Meridian Altitude	$12 \quad 40$
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Remains	$17 \quad 16$
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Half is the Complement Latitude	$8 \quad 38$
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	From $90 \quad 00$
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So the Latitude is South	$81 \quad 22$
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Then from the greater Meridian Altit.	$29 \quad 56$
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Take the Complement Latitude	$8 \quad 38$
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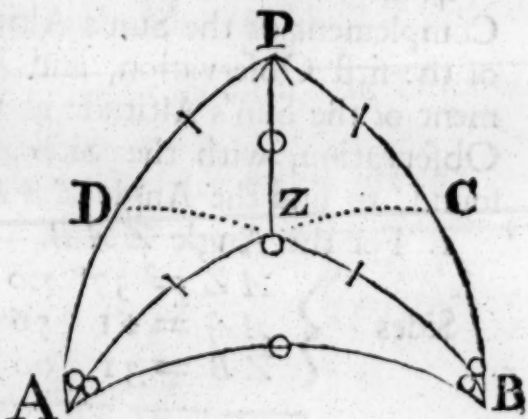
Remains Sun's Declination South	$21 \quad 18$
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Thus far we have shewn how to find the Latitude of the Place, by taking the Sun or Star upon the Meridian; but it frequently happens, that when the Sun or Star is on or near the Meridian, that then the Air is Cloudy, and so hinders a Meridian Altitude for many Days; so that the Mariner is oblig'd to trust to his dead Reckoning, until he can come to rectify it by a celestial Observation. To remedy this

this we shall shew how to find the Latitude by observing the Sun or Star upon any Azimuth.

Example. Admit a Ship at Sea in which an Altitude of the Sun in the Forenoon is observed to be 53° and $4\frac{1}{2}$ Hours after by a Watch, his Altitude is found by the Quadrant to be 59° . I demand the Latitude of the Ship, Suppose She has kept in the same Parallel during the time between the two Observations?

In the adjacent Figure let P , be the North Pole, Z the Zenith, A the first Observation, B the second, in which Triangles are given, AP the Complement of the Sun's Declination, or its distance from the North Pole, at the time of the first Observation $67^{\circ} 49'$, BP the distance of the Sun from the North Pole $= 67^{\circ} 51'$ at the time of the second Observation, and the Angle APB , the time between the two Observations $= 67^{\circ} 30'$. And first for the side AB , let fall the perpendicular ZD , then in the rectangled spherical Triangle BDP say,



1. As <i>Ct.</i> PB	$67^{\circ} 51'$	—	9.609674	}
To Radius	90 00	—	10.000000	
So <i>Cs</i> $\angle DPB$	67 30	—	9.582840	
To $\angle DP$ Sub.	43 14	—	9.973166	
From AP	67 49			
Rem. $A. D.$	24 35			
As <i>Cs.</i> DP	43 14	Co Ar.	0.137529	
To <i>Cs.</i> AD	24 35	—	9.958734	
So <i>Cs</i> BP	67 51	—	9.576379	
To <i>Cs.</i> AB	61 56	—	9.672642	

B 2

2. Fo

2. For the Angle ABP .

As $S. AB$	$61^{\circ} 56'$	Co Ar.	0.054334
To $S. < APB$	$67 \quad 30$	—	9.965615
So $S. AP$	$67 \quad 49$	—	9.966602
To $S. < ABP$	$75 \quad 49$	—	9.986551

3. For the Angle BAP .

As $S. AB$	$61^{\circ} 56'$	Co Ar.	0.054334
To $S. < APB$	$67 \quad 30$		9.965615
So $S. PB$	$67 \quad 51$		9.966705
To $S. < BAP$	$75 \quad 51$		9.986654

4. In the Triangle AZB are known, AZ the Complement of the Sun's Altitude 37° at the time of the first Observation, and ZB 31° the Complement of the Sun's Altitude at the time of the second Observation, with the Side AB $61^{\circ} 56'$ just now found, to find the Angle ZAB and ZBA .

1. For the Angle ZAB .

Sides	{	$AZ = 37^{\circ} 00$
		$AB = 61 \quad 56$
		$ZB = 31 \quad 00$

Sum =	129	56	
Half =	64	58	$64^{\circ} 58'$
	AB	$61 \quad 56$	AZ $37 \quad 00$

Differences	3	2	X	27	58
$S. AZ$	—	37	00	Co Ar.	0.220537
$S. AB$	—	61	51	Co Ar.	0.054334
$S. X$	—	3	2	—	8.723595
$S. X$		27	58	—	9.671134

Sum of the Logarithms		18.669600
Half is = Sine of	12	29
Double	24	58 = $< ZAB$.

5. For

5. For the Angle ZBA .

Sides	$\left\{ \begin{array}{l} AZ = 37 \text{ } 00 \\ AB = 61 \text{ } 56 \\ ZB = 31 \text{ } 00 \end{array} \right.$	
Sum	$= \text{---} 129 \text{ } 56$	$\text{---} 129^{\circ} 56'$
Half	$64 \text{ } 58$	$64^{\circ} 58'$
AB	$= 61 \text{ } 56$	$ZB = 31 \text{ } 00$
Difference	$3 \text{ } 2$	$X = 33 \text{ } 58$
$S. ZB$	$31 \text{ } 00$	$\text{Co Ar. } 0.288161$
$S. AB$	$61 \text{ } 56$	$\text{Co Ar. } 0.054334$
$S. X$	$3 \text{ } 2$	8.723595
$S. X$	$33 \text{ } 58$	9.747187
Sum of the Logarithms		18.813277
Half, is Sine of	$14^{\circ} 46\frac{1}{2}'$	$= 9.4066385$
Double	$29 \text{ } 33$	$= \angle ZBA$

Or the Angle ZBA may be found by the Sines of opposite Parts thus:

As $S. ZB$	$31^{\circ} 00'$	$\text{Co Ar. } 0.288161$
To $S. \angle ZAB$	$24 \text{ } 58$	9.625406
So $S. AZ$	$37 \text{ } 00$	9.779463
To $S. \angle ZBA$	$= 29 \text{ } 33$	9.693030
Angle ABP	$= 75 \text{ } 49$	
Rem. $\angle ZBP$	$= 46 \text{ } 16$	

6. Lastly, For the Side ZP , being the Complement of the Latitude of the Place of Observation in the oblique angled spheric Triangle ZPB .

As $Ct. ZB$	$31^{\circ} 00'$	10.221226
To Radius	$90 \text{ } 00$	10.000000
So $Cs. ZBC$	$46 \text{ } 16$	9.839668
To $t. BC$ Sub.	$22 \text{ } 33$	9.618442
From BP	$67 \text{ } 51$	
Rem. CP	$45 \text{ } 18$	
As $Cs. BC$ Co Ar.	$22 \text{ } 33$	0.034542
To $Cs. CP$	$45 \text{ } 18$	9.847199
So $Cs. ZB$	$31 \text{ } 00$	9.933066
To $S. of the Lat. North$	$40 \text{ } 45$	9.814807

But

But here, if the Ship doth not keep in a Parallel during the time between the two Observations, there will arise a small Error, tho' inconsiderable in this Case; but to remedy this Inconveniency, the first clear Evening take the Altitudes of two known Fix'd Stars, which may be done with the Quadrant by one Observer only, but as he takes the Altitudes, let some Assistant on Board set them down, then the Difference between the Right Ascensions of the said Stars is the Angle at the Pole, with this, and their Declinations proceed to find the Latitude of the Ship at the time of the Observation; as has been taught in the Sun abovementioned.

This Quadrant is also useful in finding the Variation of the magnetical Needle at Sea, as shall be made appear by this Example. Being at Sea in the Latitude of $37^{\circ} 20'$ North, on the 20th Day of *December* 1738, the Sun's Altitude is supposed to be observed in the Forenoon (by our new Quadrant, as we have above directed) to be $25^{\circ} 40'$, What's the Sun's Azimuth from the South, and the Variation of the Compass at that Place of Observation?

Note, Here are four Varieties in finding the Variation of the Compass at Sea. (1.) The Ship being in North Latitude, the Sun having North Declination. (2.) The Ship being in North Latitude, and the Sun having South Declination. (3.) The Ship being in South Latitude, and the Sun having South Declination. (4.) The Ship being in South Latitude, and the Sun having North Declination. *Fig. 1. Page 13.* may serve our Purpose well enough, Pole $\odot Z = 64^{\circ} 20'$ the Sun's distance from the Zenith or Complement of the Altitude, $ZP = 52^{\circ} 40'$ the Complement of the Latitude, to find the Angle $\odot ZP$ the Sun's Azimuth from the North, whose Complement to a Semicircle, is the Angle $\odot ZA$ the Sun's Azimuth from the South, *See the Work*

$\odot P =$

[17]

☉ P =	113° 8'	}	
☉ Z =	64 20		
Z P =	52 40		
Sum	230 8		
Half	115 4		115° 4'
☉ Z =	64 20	}	Z P = 52 40
X =	50 44		X = 62 24
S. ☉ Z =	64 20	}	Co Ar. 0.045117
S. Z P =	52 40		Co Ar. 0.099567
S. X =	50 44		9.888858
S. X =	62 24		9.947533
Sum Logarithm			19.981075
Sine of	78 5		9.9905375
Double =	156 10	☉ Azimuth from the North.	
From	180 0		
	23 50	Azimuth from the South.	

Now, suppose you find by the Azimuth Compass, the Sun's Azimuth from the North to be $144^{\circ} 18'$, then the Variation is $11^{\circ} 52'$ West. For, First, if the Sun's Azimuth from the North in the Forenoon be more by Calculation than that by Observation by the Azimuth Compass, their difference is the Variation East; but if it be less, the Variation is West-erly. 2. In the Afternoon, if the Sun's Azimuth from the North by Calculation, be greater than the Azimuth by the Compass, the Variation is Westerly. But if the Azimuth from the North be less than that by the Compass, the Variation is Easterly.

Thus have we given the uses of this Excellent Quadrant in Navigation, which we doubt not that when the Mariner comes to make use of, and practise at Sea, he will find it to exceed all other as much in Ease and Exactness, as it doth in Magnitude and Simplicity of Workmanship.



CHAP. II.

The Use of the Quadrant in
ASTRONOMY.

ASTRONOMY is a Science so well known in these Days, that we need not say any thing to recommend it to the learned World; but when we consider what vast expence the Ancients were at in providing costly Instruments for only taking the Altitudes and Distances of the Stars, we may now be struck with Admiration, to see that one, not the thousand part of the Cost nor Magnitude, will perform to a greater exactness than theirs could do. Surely then, this great improvement deserves the greatest Encouragement from Men of Skill that can possibly be thought on.

How to take an Observation.

Now in order to make an Observation, on Land it will be necessary that there be a Brass Socket fastned to the back side of the Quadrant in order to fix it upon a Pedestal, or three legged Staff, that so it may easily be moved to any Altitude and Azimuth, then turning the Sights *A* and *B* to the Object, till you can see the Sun or Star through them, the Index *E* will shew the Degree upon the Limb, and the Index *F* the Minutes, and the Index *G* the Seconds of Altitude at the same time, for then by pulling the Tricker *H* all the three Hands stop at their

their proper Places: and this is all that is required in taking of an Observation.

Before we come to Practice, it will be necessary to shew what the Right Ascension of the Sun and Stars are, in order to find the true Hour of the Night by the Instrument.

What Right Ascension is.

The Right Ascension of the Sun or Star, is that Degree of the Equinoctial accounted from the beginning of Aries, which rises with it in a Right Sphere; or it is that Degree of the Equinoctial (accounted as before) which comes to the Meridian with the Sun or Star in an Oblique Sphere.

Hence, because our Astronomical Tables are adapted to the Meridian of *London*, the Sun's Right Ascension must be increased or diminished one Minute for every 90° or 6 Hours difference of Meridian East or West from that of *London*, and so in Proportion; for because the Sun's Right Ascension is increased Daily about 4' in Time, that is 4' in 24 Hours, 1' will answer to 6 Hours, 2' to 12 Hours or 180° of Longitude East or West from *London*, to be added to, or Subtracted from, the Sun's Right Ascension at *London*, will give the Sun's Right Ascension under any other Meridian.

Suppose, for Example, it were required to find the Sun's true Declination and Right Ascension at *London* on the 17 Day of *January* 1739, at three Hours twenty Minutes in the Afternoon? The Sun's true Place the 17 Day at Noon (according to the Tables of our Astronomical Friend Mr. *Charles Leadbetter*) is $\approx 8^{\circ} 14' 4''$, and the 18 Day at Noon is $\approx 9^{\circ} 15'$ the Diurnal Motion is $1^{\circ} 0' 56''$, Now say, As 24 Hours, is to the Sun's Diurnal Motion $1^{\circ} 0' 56''$, So is the time from Noon three Hours twenty Minutes, to $8' 28''$ the Sun's Motion in that time,

which added to the Sun's Place the 17 Day at Noon $\approx 3^{\circ} 14' 4''$ gives $\approx 8^{\circ} 22' 32''$, his Place in the Ecliptic at three Hours twenty Minutes past Noon the same Day. And thus if you have not Astromical Tables to Calculate by, may you find the Sun's true Place in the Ecliptic to any other intermediate Hour between the Noon of one Day, to the Noon of the next Day, by having an Ephemeris that gives the Sun's Place at Noon.

To find the Sun's Declination.

The Sun's Declination is always found by this Analogy.

Example. To the Place of the Sun above found,

As Radius	—	$90^{\circ} 00' 00''$	10.0000000
To S. of $\odot$ Dist. à $\vee$	51	37 28	9.8942930
So S. Obliq. of Eclipt.	23	29 00	9.6004090
To S. Declination South	18	12 13	9.4947020

Sun's Right Ascension found.

The Sun's Right Ascension is always found by this Analogy.

Example. To the Place of the Sun above found,

As Radius]	—	$90^{\circ} 00' 00''$	10.0000000
To C. S. Obliquity	23	29 00	9.9624527
So T. of $\odot$ Dist. à $\vee$	51	37 28	10.1013319
To T. of — Subt.	49	11 33	10.0637846
From —	—	<u>360 00 00</u>	
Rem. Sun's Right A.	310	48 27	

This being reduced into Time, by allowing 15° to one Hour, and $15'$ in Motion to $1'$ in Time, it will

will be 20 Hours, 43' 13" 48''' the true R. Angle of the Sun, in time to his Place above found.

We have said above, that for every 6 Hours difference of Meridians from *London*, there must be an allowance of 1' in the Sun's Right Ascension. Now, Suppose it be Noon at *Fort St. George* in the *East Indies* on the 17 of *January* 1739, I demand the Sun's Place, Declination, and Right there.

Fort St. George lieth 5 Hours 24 Minutes to the East of the Meridian of *London*, therefore it is but 36 past 6 in the Morning at *London*, to which our Astronomical Tables are fitted.

Equal Time.	Long. ☉.	Anom. ☉.	At Fo.S.George
	^s 0 ' "	^s 0 ' "	Declination.
Anno 1739	9 20 31 30	6 12 7 11	° ' "
Jan. 16	15 46 13	15 46 10	18 17 58 S.
Hour 18	44 21	44 21	
Min. 36	1 29	1 29	R. Ascension.
Mean Mot.	10 7 3 33	6 28 39 11	310° 25' 31"
Equat. add	0 56 48		In Time.
Sun's true Pl.	10 8 00 21		20 ^h 41' 42" 4'''

Again, Let us suppose at *Jamaica* on the same Day to be Noon there, I demand the Sun's Place, Declination, and Right Ascension.

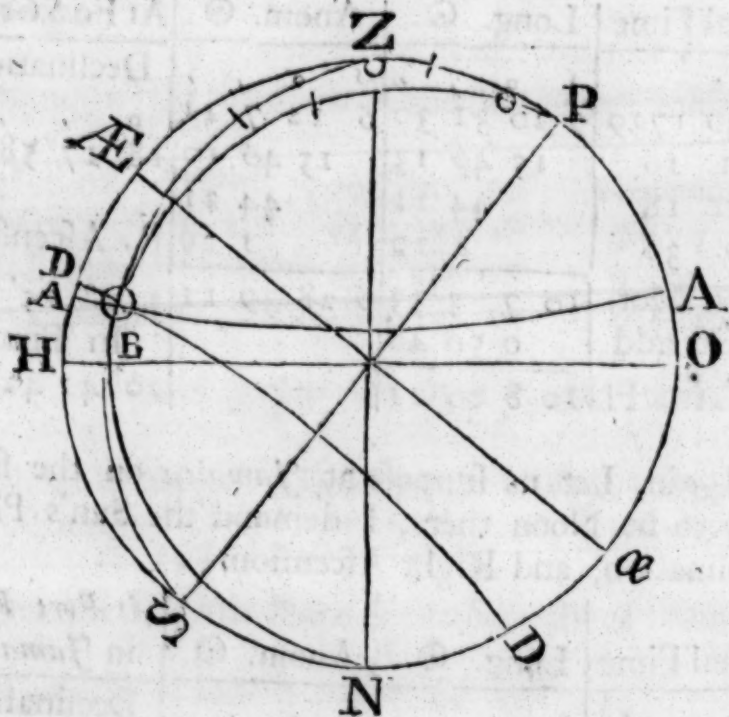
Equal Time.	Long. ☉.	Anom. ☉.	At Port Royal in Jamaica.
	^s 0 ' "	^s 0 ' "	Declination.
Anno 1739	9 20 31 30	6 12 7 11	18° 11' 5" S.
Jan. 17	16 45 22	16 45 9	
Hour 5	12 19	12 19	R. Ascension.
Min. 4	10	10	310° 52' 55"
Mean Mot.	10 7 29 21	6 29 4 49	In Time.
Equat. add	0 57 35		^h ' " "
Sun's Place	10 8 26 56		20 43 31 40.

We

We having now shewn how to take an Altitude, to find the Sun's Place, Declination and Right Ascension, it remains now to shew how to find the true Hour of the Day by the Sun, and the true Hour of the Night by the Stars. And first by the Sun.

Example. Suppose at *London, December 3.* I observe the Sun's Altitude in the Forenoon to be $13^{\circ} 20' 37''$, the Sun's Declination $23^{\circ} 14' 40''$ South, I demand the true Hour of the Day.

The Refraction answering to this Altitude is $3' 25''$ to be Subtracted, so the true Altitude is $13^{\circ} 17' 12''$. See *Leadbetters Astronomy, Page 63 of Vol. 2.*



In this Scheme, the Circle *HZON*, represents the Meridian of *London*, *Z* the Zenith, *N* the Nadir, *S* the South Pole, *P* the North, *SP* the Earth's Axis, *AE* ∞ the Equinoctial, *DD* a Parallel of Declination $23^{\circ} 14' 40''$ South, *AA* a Parallel of the Sun's Altitude cutting the Parallel of the Sun's Declination in $\odot$ through which draw the Oblique Circle *Z* $\odot$ *N*, and

and $P \odot S$; So have we the Oblique Spherical Triangle $\odot ZP$, in which we have given $\odot P = 113^\circ 14' 40''$ the Sun's Distance from the North Pole, that is the Declination added to 90° . and $\odot Z = 76^\circ 42' 48''$, the Sun's Distance from the Zenith, or Complement of his Altitude, $ZP = 38^\circ 28'$ the Complement of the Latitude, to find the Angle $\odot PZ$, being the time between Noon, and the time that the Observation was made.

Operation.

$$\begin{array}{rcl} \odot Z & = & 76^\circ 42' 48'' \\ ZP & = & 38 \quad 28 \quad 00 \\ \odot P & = & 113 \quad 14 \quad 40 \text{ Complement } 66^\circ 45' 20'' \end{array}$$

$$\text{Sum} = 228 \quad 25 \quad 28$$

$$\text{Half} = 114 \quad 12 \quad 44 \quad \text{---} \quad 114^\circ \quad 12' \quad 44''$$

$$\odot P = 113 \quad 14 \quad 40 \quad \text{---} \quad ZP = 38 \quad 28 \quad 00$$

$$X = 0 \quad 58 \quad 4$$

$$X = 75 \quad 44 \quad 44$$

$$S. \odot P = 66 \quad 45 \quad 20 \text{ Co Ar. } 0.0367651$$

$$S. ZP = 38 \quad 28 \quad 00 \text{ Co Ar. } 0.2061683$$

$$S. X = 75 \quad 44 \quad 44 \text{ --- } 9.9864187$$

$$S. X = 00 \quad 58 \quad 04 \text{ --- } 8.2276284$$

$$\text{Sum, Logarithms} \text{ --- } 18.4569805$$

$$\text{Sine of } 9^\circ 44' 36'' = 9.2284902$$

Double = $19 \quad 29 \quad 12 = 1^h 17' 56'' 48'''$ taken from 12 Hours leaves $10^h 42' 3'' 12'''$ the true Time of the Day.

2. To find the true Hour of the Night by the Stars.

For this purpose we have incerted the following Table of Fixed Stars, with their Declinations and Right Ascensions to the Year 1740, which will serve for this Age without any Sensible Error.

1. To

1. To find the Time of the Star's Southing.

First, Find the Sun's Right Ascension by the Rules above given, which Subtract from the Right Ascension of the Star in the following Table, and the remainder is the time that that Star will be upon the Meridian, or South.

2. Then with your Instrument take the same Star's Altitude, with which enter the Table of Refraction in Mr. Leadbetter's *Astronomy*, pag. 63. or his *Uranoscopia*, pag. 540, &c. which subtract from the Altitude taken by the Quadrant, and the remainder is the true Altitude of the Star at the time of Observation; then proceed to find the Angle at the Pole, as has been shewn in the Example of the Sun, and then Observe if the Star be short of the Meridian you subtract the Angle at the Pole from the time of its Southing, the remainder is the true time of the Night: But if the Star be past the Meridian, the quantity of the Angle at the Pole must be added to the time of the Stars Southing, and that Sum is the true Hour of the Night: One Example will make it very plain.

Let the Altitude of the *Little Dog Procyon* be $20^{\circ} 15' 30''$, the Refraction being Deducted: At *London December 17, 1739*, short of the Meridian. I demand the true Hour of the Night?

1. For the time of the Star's Southing.

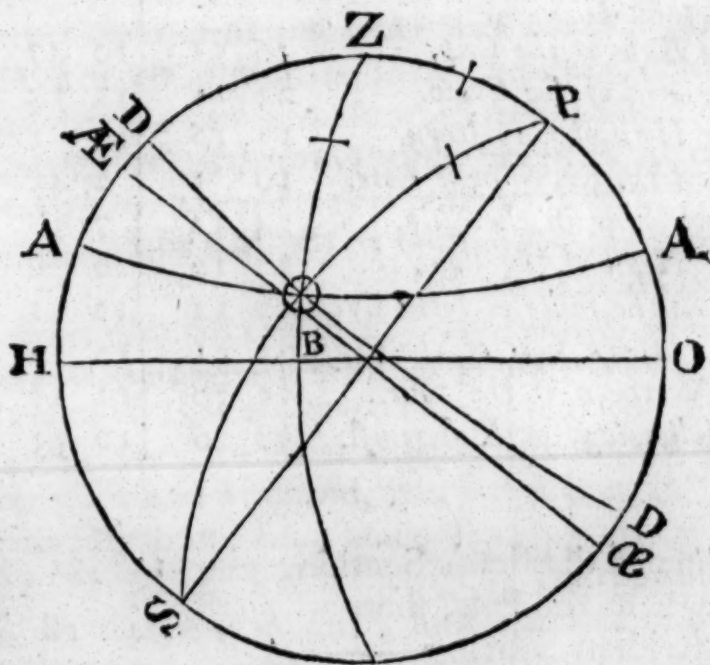
Right Ascension of <i>Procyon</i>	7 ^h 25' 44"
Right Ascension of the Sun Subt.	18 33 53
Time Star's Southing at Night	12 51 51

2. For

For the Angle at the Pole.

Operation.

$\odot P =$	84°	07'	22''		
$\odot Z =$	69	44	30		
$ZP =$	38	28	00		
Sum =	192	19	52		
Half =	96	09	56	96°	09' 56''
$\odot P =$	84	07	22	$ZP =$	38 28 00
X	12	02	34	X	57 41 56
S. $\odot P =$	84	07	22	Co Ar.	0.0022888
S. $ZP =$	38	28	00	Co Ar.	0.2061683
S. X =	12	02	34	—	9.3194015
S. X =	57	41	56	—	9.9269860
Sum of the Logarithms				—	19.4548446
Half S	32°	15'	58''	---	9.7274223
Double =	64	31	56	= time	4 ^h 18' 7" 44"



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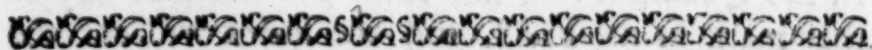
Stars

Stars Names.	Declin.	R. Ascen.	Mag.
<i>The Breast of Cassionia Scheder.</i>	55 3 N	0 26	2
<i>Head of Medusa Algol.</i>	39 54	2 52	1
<i>Brightest of the Seven Stars, Pleiades.</i>	23 15	3 32	2
<i>South Eye of the Bull, Aldebaran.</i>	15 57	4 21	1
<i>The Goat, Capella.</i>	45 42	4 58	1
<i>Middle Star in Orion's Belt.</i>	1 25 S	5 23	2
<i>The Great Dog, Sirius.</i>	16 22 S	6 35	1
<i>The Little Dog, Procyon.</i>	5 52 N 38	7 25 44	1
<i>The Heart of Hydra.</i>	7 31 S	9 16	1
<i>The Lyon's Heart, Regulus.</i>	13 16 N	9 55	1
<i>The Virgins Spike.</i>	9 46 S	13 12	1
<i>Arcturus.</i>	20 37 N	14 5	1
<i>The Scorpions Heart, Arctures.</i>	25 49 S	16 14	1
<i>The Shining Harp.</i>	38 34 N	18 29	1
<i>The Brightest in the Eagle.</i>	8 11 N	19 40	1
<i>The Mouth of the Souther Fish, Fomahant.</i>	31 2 S	22 44	1
<i>In the Base of the Cup.</i>	16 51	10 47	3
<i>In the Bill of the Crow.</i>	23 12	11 54	4
<i>Upper Horn of Capricorn.</i>	13 16	20 3	3
<i>First in the River next Cete.</i>	10 1	2 43	3
<i>Highest Star in the Ship.</i>	24 12	7 38	3
<i>In the Head of the Peacock.</i>	57 10	20 8	2
<i>First in the middle of the Cross.</i>	57 11	12 1	3
<i>The Southern Foot of the Cross.</i>	61 31	12 12	2
<i>The Northern of the four.</i>	55 30	12 17	2
<i>The following, or Eastermost.</i>	58 6	12 33	2

Time of the Star's Southing — 12^h 51' 51"
 Angle at the Pole, short of } — 4 18 8
 the Meridian Subt. — }
 True time of the Night — 8 33 43

This

This Quadrant is also useful to the Astronomer in taking the Distances of a Planet from Fixed Stars, by turning it into an Oblique Position, and making use of the Index *IK*, from which Observations may the true Longitudes, Latitudes, Declinations and Right Ascensions be most accurately determin'd; and also by it may the Earth's Aphelion, and Annual Inequality be determin'd, as also the Earth or Sun's Ingress into any Point of the Ecliptic, and the Obliquity of the Ecliptic most exactly determin'd; as is shewn by our Excellent Astronomer Mr. *Leadbetter*, in his *Uranoscopia* Page 21, &c. No wonder then, if *Tycho Brahe* and the rest of the Ancients differed so much from the truth in these, when 'tis plain the fault lay in their Instruments and not in their Skill, for had they had such a Quadrant as we are now describing, they would have been no ways behind the Astronomers of our Age: But alas! they were at great Expence, made large Instruments, and when done, could not come near the Mark. But now by this portable Quadrant, we are enabled to measure the greatest Distances in the Heavens that come within the reach of our Sight.

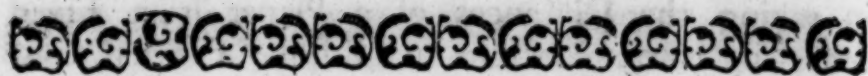


Advertisement to the Reader.

ALL who have seen this Instrument, and are ever so little versed in Navigation are convinc'd it surpasses all that are made use of at present. And those skill'd in Sea-Affairs say, that Sir *Cloudsley Shovel*, and those with him, had never been lost had one such Instrument been amongst them.

Febr. 19. 1734. I have seen the Instrument describ'd in this Paper and do, on Examination, find it very useful, and to agree exactly with its Description.

J. T. Desaguliers, F. R. S.



CHAP. III.

*The use of the Quadrant in Surveying
of Land.*

SURVEYING of Land principally depends upon Instruments for taking of Angles, and such are the Plane Table, Semicircle, Circumferentor, or Theodolite; Now our Quadrant having a Box and Needle fitted to it, placed upon a three Legged Staff, by help of a Ball and Socket will take an Angle Horizontal, as well as it did a Vertical one; for place the Center of the Index *IK*, upon the Center of the Quadrant at *C*, then direct the Sight of the Index to any object in the Field, (it lying parallel to the Side of the Quadrant *AB*,) here let the Quadrant rest, and move the Index to any other mark in the Field, and the Index will cut the quantity of the Angles in Degrees, on the Limb, and the Minutes are shewn by the Index at *F*.



CHAP. IV.

The use of the Quadrant in Dialling.

THIS Quadrant is also very useful to the Diallist; First in finding the Declination of a Plane, which is best done by the Sun's Azimuth, as we have shewn how to find in the First Chapter hereof, when we treated of Navigation. See *Leadbetter's Mechanick Dialling*. And, Secondly, it is useful to the Diallist in setting up his Horizontal Dial true, by taking the Sun's Altitude, and with that, the Latitude of the Place and the Sun's Declination, find the true Hour of the Day as has been taught in the First Chapter of this Treatise. See *Leadbetter's Uranoscopia*, Page 133.

Some Observations made Octob. 29. 1739.

AT the request of several Gentlemen I went to the *Nore*, in order to try Mr. *Barston's* New-invented Quadrant, which requires no Shade from the Sun, nor any visible Horizon. On the 30th at Night I took several Altitudes of the Moon, in Company with several Gentlemen belonging to his Majesty's Yard at *Chatham*, which were as follows.

22° 17'	Then Stoping to look over the Ob-
22 18	servations and admiring how they a-
22 18½	greed, we began to take these other
22 20	Altitudes following, which also agreed
22 25	very well.

22°	42'
22	44
22	42
22	45
22	47

November 1. 1739. at *Sheerness*, by the Altitude of the Pole Star.

Altitude of the Pole Star	————	49° 15'
Pointer bore N.W. by W. therefore		} 2 13
the Pole Star was below the Pole		
Which, added to the Altitude, give		} 51 28
for the Latitude of <i>Sheerness</i>		

At the same Place, by the Sun's Meridian Altitude.

Sun's Meridian Altitude	————	20 14½
Complement of Altitude	————	69 45½
Declination Subtract	————	18 17
Latitude	————	51 28½

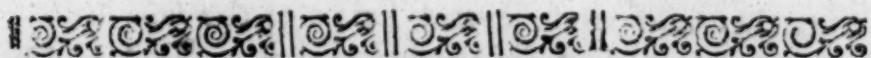
November

November 3d, on Board his Majesty's Ship the *Chatham*, Capt. *Strange*, at the *Nore*, we made several Observations both before and after the Sun came to the Meridian, keeping near equal Time; then adding them together and dividing that Sum by the number of Observations.

The Sum Altitude	_____	20	3 $\frac{1}{2}$
Complement	_____	69	56 $\frac{1}{2}$
Declination Subtract	_____	18	28
Latitude of the <i>Nore</i>	_____	51	28 30

And for the Simple Construction, and the Ease in Managing, and Exactness in its Performance, it far Exceeds all other that I have Tri'd.

John Renshaw.



The Report of the Lord's of the Admiralty to his Majesty, concerning Mr. John Barston's New Invented Quadrant.

Sire,

YOUR Majesty having returned us the Petition of *John Barston* Watchmaker, in which he demonstrates that he hath invented an Universal Quadrant, which takes not only the Degrees, but even Minutes and Seconds of the Height or Altitude of the Sun, when there is no visible Horizon; and when the Sun casts no Shade, (as often happens in Dark and Hazy Weather;) and which also serves to take Observations of the Moon and fixed Stars by Night, so as to determine exactly the Latitude of Places: Which Instrument (as he alledges) hath been approved of by the Master, Guardians, and Assistants of Trinity House, by Dr. *Halley* your Majesty's Astronomical Observator; and which also hath been
 tried

tryed on Board your Majesty's Ship the *Grafton*. And whereas the said *Barston* has Spent a great deal of Time and Money in inventing and bringing to Perfection the said Instrument; he humbly Petitions your Majesty out of your Royal Bounty, to grant him some Recompence, that might enable him to make his Invention of general use to your Majesty's Navy, as well as to all Sailors whatever.

Your Majesty having commanded us to consider the Affair, and make our Report of what ought to be done therein. We have the honour to inform You that the Petitioner having brought us his Instrument, we order'd Captain *Nicholas Haddock* of the *Grafton* Man of War to make Trial, and report his Opinion as to the usefulness of the said Quadrant, and the Captain having represented in his Letter of the 25 of July 1732, that they had made several Trials of the said Instrument, not only on Shipboard and in a Boat, at the Buoy in the Nore, but likewise on Shipboard as low as the Buoy of the *Spaniard*, where you lose sight of Land to the Northward, in order to have an Horizon, and that they found this new Quadrant agreed with the others, and that the said Captain, as well as others who tried the Instrument, were of Opinion it would be of much greater use at Sea, than the Common Quadrants, in as much as an Horizon is always given, and because they can take the Height of the Sun with it, when they cannot with the others for want of a Shade. And in short, that by Experience it gives the Latitude to the greatest Exactness. This is the Case of your Petitioner, to whom we have given twenty Guineas out of the Contingences of our Office, in Consideration of the Expence which he hath been at in preparing his Instrument, of which, with Submission, we make our most humble Report to your Majesty.

Office of Admir.
Octob. 29. 1739.

CH. WAGER.
A. HAMILTON.
F. WINNINGTON.

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